

Australian Standard[®]

**Information technology—Biometric data
interchange formats**

Part 3: Finger pattern spectral data



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 - Attorney General's Department
 - Australian Business Limited
 - Australian Electrical and Electronic Manufacturers Association
 - Centrelink
 - The Biometric Institute
-

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Australian Standard[®]

Information technology—Biometric data interchange formats

Part 3: Finger pattern spectral data

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PREFACE

This Standard was prepared by the Standards Australia Committee IT-032, Biometric and Identification.

The objective of this Standard is to make available to the Australian biometrics community the core ISO SC37 standards published over the last 24 months, specifically the biometric data interchange formats finger pattern spectral data.

This Standard is identical with, and has been reproduced from ISO/IEC 19794-3:2006, *Information technology—Biometric data interchange formats—Part 3: Finger pattern spectral data*.

As this Standard is reproduced from an international standard, the following applies:

- (a) Its number appears on the cover and title page while the international standard number appears only on the cover
- (b) In the source text ‘this part of ISO/IEC 19794’ should read ‘this Australian/New Zealand Standard’.
- (c) A full point substitutes for a comma when referring to a decimal marker.

<i>Reference to International Standard</i>		<i>Australian Standard</i>	
ISO/IEC		AS ISO/IEC	
19784	Information technology—Biometric application programming interface	19784	Information technology—Biometric application programming interface
19784-1	Part 1: BioAPI specification	19784.1	Part 1: BioAPI specification
19785	Information technology—Common Biometric Exchange Formats Framework	19785	Information technology—Common Biometric Exchange Formats Framework
19785-1	Part 1: Data element specification	19785.1	Part 1: Data element specification

The term ‘informative’ has been used in this Standard to define the application of the annex to which it applies. An ‘informative’ annex is only for information and guidance.

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INTRODUCTION

In the interest of implementing interoperable personal biometric recognition systems, this part of ISO/IEC 19794 establishes a data interchange format for finger pattern spectral data. The goal of this part of ISO/IEC 19794 is to allow the exchange of local or global spectral data derived from a fingerprint image without the exchange of the entire image. This will allow more compact data representations.

This part of ISO/IEC 19794 allows for representation of spectral components, such as Discrete Fourier Transform and (single-scale) Gabor Filter components, extracted from global or stationary (not image dependent and not varying over the image) local overlapping or non-overlapping uniform-sized regions of the original intensity (non-color) image. Some or all of the extracted spectral components will be stored in the data format, depending upon the implementation. This part of ISO/IEC 19794 does not accommodate multi-scale (wavelet) decompositions.

There are fingerprint recognition algorithms that use spectral data directly for pattern matching. Spectral data-based recognition algorithms process “globally” local sections (cells) of biometric images, in contrast to morphological-based algorithms, which extract singularities in the morphological features. At the current time, there is no established mechanism for the interchange of finger pattern spectral information for use with spectral-based fingerprint matching algorithms.

By establishing a standard for spectral-based representation of fingerprints, we

- allow interoperability among fingerprint recognition vendors based on a small data record;
- support the proliferation of low-cost commercial fingerprint sensors with limited coverage, dynamic range, or resolution;
- define a data record that can be used to store biometric information on a variety of storage mediums (including, but not limited to, portable devices and smart cards);
- encourage the adoption of biometrics in applications where interoperability is required.

The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning the quantized co-sinusoidal triplets method of formatting the pattern spectral data. ISO and IEC take no position concerning the evidence, validity and scope of this patent right. The holder of this patent right has assured the ISO and IEC that he/she is willing to negotiate licenses under reasonable and non-discriminatory terms and conditions with applications throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO and IEC. Information may be obtained from:

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L3R 8E3

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AUSTRALIAN STANDARD

Information technology — Biometric data interchange formats —**Part 3:
Finger pattern spectral data****1 Scope**

This part of ISO/IEC 19794 specifies the interchange format for the exchange of spectral-based fingerprint data.

2 Conformance

A biometric system or algorithm conforms to this part of ISO/IEC 19794 if it satisfies the mandatory requirements for the generation of the finger pattern spectral data as defined in Clause 7 and the generation of the data record as described in Clause 8.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 19784-1:2006, *Information technology — Biometric application programming interface — Part 1: BioAPI specification*

ISO/IEC 19785-1:2006, *Information technology — Common Biometric Exchange Formats Framework — Part 1: Data element specification*

ANSI/NIST-ITL 1:2000, *Standard Data Format for the Interchange of Fingerprint, Facial, & Scar Mark & Tattoo (SMT) Information*

ANSI/IEEE Std 754-1985, *IEEE Standard for Binary Floating-Point Arithmetic*

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1**biometric data**

biometric sample at any stage of processing, biometric reference, biometric feature or biometric property

NOTE For the purpose of this document, biometric data refers to finger pattern spectral data, quality data, and other data derived from an acquired biometric sample.

4.2

biometric feature

concise representation of information extracted from an acquired or intermediate biometric sample by applying a mathematical transformation

NOTE 1 The use of this term should be consistent with its use by the pattern recognition and mathematics communities.

NOTE 2 For the purpose of this document, biometric features are finger pattern spectral components.

4.3

biometric sample

data obtained from a biometric device, either directly or after processing

4.4

acquired biometric sample

analog or digital representation of biometric characteristics directly taken from an individual by a sensor

NOTE 1 For this document, the sensor will acquire representations of fingerprints.

NOTE 2 An acquired biometric sample will usually retain the full resolution and spatial extent permitted by the sensor.

4.5

intermediate biometric sample

biometric sample that is obtained by modifying an acquired biometric sample to allow better feature extraction, and that is not suitable as yet for automated matching in the biometric system under consideration

EXAMPLE Examples of modifications include cropping, down-sampling, compression, conversion to data interchange formats standard and image enhancement.

NOTE For the purpose of this document, the concept of an intermediate biometric sample relates to finger pattern.

4.6

biometric system

an automated system capable of:

- capturing an acquired biometric sample from an individual;
- optionally extracting biometric features from that acquired biometric sample;
- comparing the biometric features (or acquired biometric sample) with those contained in one or more reference templates or models;
- deciding how well they match; and
- indicating whether or not a recognition has been made.

4.7

bit-depth

the number of bits used to represent a data record parameter

4.8

cell

designated array of pixels within a finger pattern

NOTE Multi-scale cells are not accommodated in this part of ISO/IEC 19794.

4.9**cell structure**

an array of pixels, each of which has a greyscale value, defined by a co-sinusoidal pattern with parameters θ , λ , and δ

NOTE This concept applies only to the quantized co-sinusoidal triplet method.

4.10**cell quality group**

square array of cells of a finger pattern for which a quality score is specified

4.11**comparison**

the process of measuring the similarity or difference between the biometric features of an acquired biometric sample and a previously stored reference template or model

4.12**core**

a singular point in the fingerprint where the curvature of the ridges reaches a maximum

NOTE For simplicity, the core can be considered as a U-turn, sometimes enclosing a few ridge endings. It serves as an approximation of the centre of the fingerprint image.

4.13**crop**

remove the outer regions of an image to reduce the size

4.14**delta**

that point on a ridge at or nearest to the point of divergence of two typelines, and located at or directly in front of the point of divergence

4.15**dimension**

number of pixels in an acquired biometric sample image either x or y direction

4.16**down-sample**

reduce the resolution of an image by re-sampling the image with a reduced number of pixels

NOTE Proper filtering is implied to prevent aliasing.

4.17**enrolment**

the process of collecting acquired biometric samples from an individual and the subsequent preparation and storage of biometric reference templates or models

4.18**finger pattern**

fingerprint image that may be processed (by cropping and/or down-sampling, for example)

NOTE For the purpose of this document, the concept of a finger pattern relates to an intermediate biometric sample.

4.19**finger pattern spectral data**

set of spectral components derived from a finger pattern

4.20**minimal spatial wavelength**

the (spatial) wavelength (measured in pixels) at which exactly two samples of an image span a complete period of a (co)sinusoidal pattern

NOTE This is therefore the maximal spatial frequency that can be supported by a sampling resolution, and is known as the Nyquist frequency. The minimal spatial wavelength is the inverse of the Nyquist frequency. Be aware the minimum Nyquist frequency is established by the resolution of the down-sampled fingerprint image. The required resolution for any subpopulation should be determined according to the application.

4.21**pad**

embed an image in a larger array (usually filled with zeroes) to produce a resulting image of greater dimension

4.22**re-sampling**

sample an image at a different frequency from that used to sample the original image

4.23**resolution**

number of pixels per unit length

NOTE Pixels per cm (ppcm) will be used in this part of ISO/IEC 19794 as the units of resolution. Note that 1 pixel per cm (ppcm) = 2.54 pixels per inch (ppi).

4.24**typeline**

two innermost ridges that start parallel, diverge and surround or tend to surround the pattern area

5 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviated terms apply.

2D	two dimensional
CBEFF	Common Biometric Exchange Formats Framework
DFT	Discrete Fourier Transform
ppcm	pixels per centimetre
ppi	pixels per inch

Variables are represented in this document by:

$a, b, c, \dots, S, T$	italicized, lower and upper case letters
$\alpha, \theta, \lambda, \dots, \Gamma$	italicized, lower and upper case Greek letters
$[a, b)$	range of values from (and including) a up to (but not including) b
$[a, b]$	range of values from (and including) a up to (and including) b
$\lfloor a \rfloor$	largest integer less than or equal to a
$\lceil a \rceil$	smallest integer greater than or equal to a

$\text{ROUND}(a)$ nearest integer to a . If a equals a half integer, then $\text{ROUND}(a)$ shall be replaced with the nearest integer larger than a .

$a(b, c)$ function, a , that accepts variables b and c as input

$|a(b, c)|$ magnitude of DFT or Gabor function, a , given inputs b and c

$\angle a(b, c)$ phase of DFT or Gabor function, a , given inputs b and c

6 Data conventions

6.1 Byte and bit ordering

Each item of information, field, or logical record shall contain one or more bytes of data. Within a record all multibyte quantities are represented in Big-Endian format. That is, the more significant bytes of any multibyte quantity are stored at lower addresses in memory than less significant bytes. The order for transmission shall also be the most significant byte first and least significant byte last. Within a byte, the order of transmission shall be the most significant bit first and the least significant bit last. All numeric values are fixed-length unsigned integer quantities, unless otherwise specified. Floating point values shall be recorded as single precision 4-byte (32-bit) values as per ANSI/IEEE Std 754–1985.

6.2 Coordinate system

The coordinate system of a fingerprint used in this part of ISO/IEC 19794 shall be a Cartesian coordinate system. Pixel locations shall be represented by their x and y coordinates. The origin of the coordinate system shall be the upper left corner of the image with x increasing to the right and y increasing downward. Note that this is in agreement with most imaging and image processing use. The pixel location of the image origin shall be (0,0). When viewed on the finger, x increases from right to left as shown in Figure 1. All x and y values are non-negative.

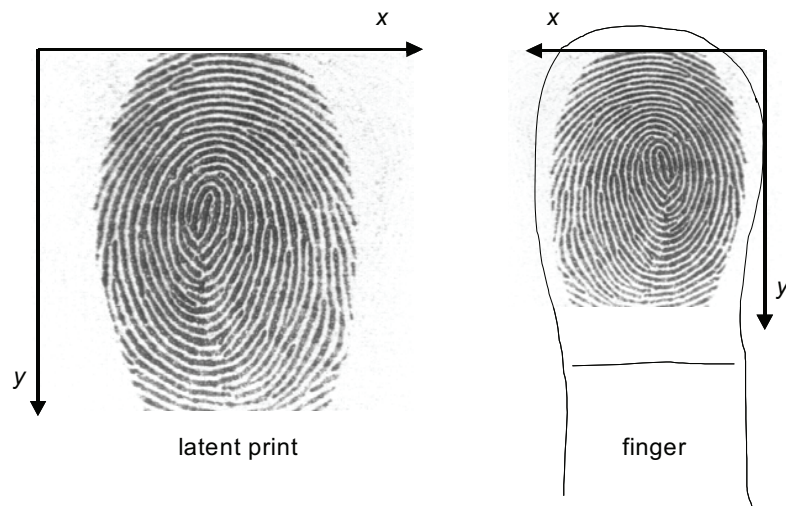


Figure 1 — Coordinate system

For the finger pattern spectral record format, the resolution of the coordinate system is specified in the record header, see 8.1.5, x (horizontal) resolution, and 8.1.6, y (vertical) resolution.

Similar to that of the image, the origin of a cell shall be the upper left pixel of the cell with x increasing to the right and y increasing downward.

6.3 Greyscale precision

The greyscale precision of the pixel data for this part of ISO/IEC 19794 shall be 8 bits, or 256 levels of grey. A black pixel will have value 0, while a white pixel will have value 255. However, the "blackest" pixel in an image may have a value greater than "0" and the "whitest" pixel may have a value less than 255.

6.4 Image polarity

Images will have dark ridges and light valleys, otherwise a conversion to this convention is required. Grey lines in figures of fingerprints presented in this part of ISO/IEC 19794 correspond to fingerprint ridges.

6.5 Angle direction of rotation

Angles shall have a range of $[0, 360)$ degrees, unless otherwise specified. An angle of 0 degrees is parallel to the x , or horizontal, axis extending from the point of origin in a positive x direction. Angles increase in a counter-clockwise rotation.

6.6 Phase and propagation angles

All phase and propagation angles introduced in this part of ISO/IEC 19794 are to be given in degrees.

7 Determination of finger pattern spectral data

7.1 Overview

To determine the finger pattern spectral data to be used to represent an acquired fingerprint image in the interchange format defined in this part of ISO/IEC 19794, the following shall be performed:

- 1) [Optional] Image pre-processing, for example, reduction in resolution and cropping of the image: conversion of the acquired fingerprint image to a cropped and down-sampled finger pattern;
- 2) Cellular partitioning: dividing the finger pattern from Step 0) into cells of size $S \times T$ pixels;
- 3) Spectral component selection: selection of the spectral components to represent each finger pattern cell.

7.2 Step 0) [Optional] Image pre-processing

Spectral pattern-based fingerprint processing may optionally perform image resolution reduction. Any resolution reduction performed should maintain compatibility with the finger characteristics of the target population (adult, child, etc.). Cropping may also occur as part of this step. If cropping is performed together with resolution reduction, it may occur either before or after down-sampling.

If performed, the result of Step 0) is a cropped and down-sampled version of the acquired fingerprint image known herein as the finger pattern. If Step 0) is not performed, the input to Step 1) below will be the acquired fingerprint image.

7.3 Step 1) Cellular partitioning

In general, cellular representation of the finger pattern data comprises dividing the central, or other, portion of the finger pattern into a grid of overlapping or non-overlapping cells. The first cell is considered to be the upper, leftmost cell within the finger pattern. The origin of the first cell may be offset from the origin of the finger pattern (as indicated by the x and y offsets shown in Figure 2). Any number of finger pattern pixels that are insufficient to create a full cell at the right of a row, or at the bottom of a column shall be excluded.

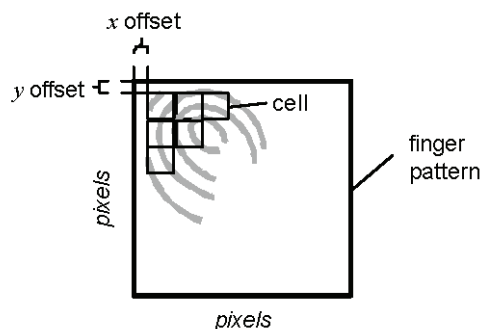


Figure 2 — Cellular partitioning of the finger pattern

At each cell, the finger pattern information will be represented by spectral components selected via one of the methods outlined in Clause 7.4.

7.4 Step 2) Spectral component selection

There are several approaches that can be taken to obtain the spectral information that will be stored to represent a finger pattern cell. Such approaches include Discrete Fourier Transforms, Gabor filtering, or selection of spectral components from a quantized set of co-sinusoidal triplets, as described below.

7.4.1 Quantized co-sinusoidal triplets

It is possible to represent the greyscale information within a finger pattern cell with the following 2D co-sinusoidal function: $Cell_{(\theta, \lambda, \delta)}(s, t) = \cos(PD \times 2\pi \times f + \delta)$, where $PD = s \times \cos(\theta) - t \times \sin(\theta)$, $f = 1/\lambda$, and s and t are the subscripts for the cell pixels on the x and y axes, respectively.

This 2D co-sinusoidal function is fully defined by the parameters θ , λ and δ , the propagation angle, wavelength and phase offset, respectively. These parameters are shown pictorially in Figure 3 below.

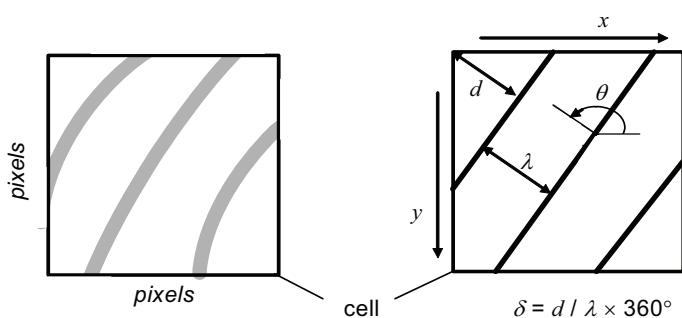


Figure 3 — Spectral component representation of a finger pattern cell

The range of each of these parameters is given below:

θ : $[0, 180)$ degrees. θ is defined as the angle of propagation of the co-sinusoidal function, where the propagation direction is measured perpendicular to the crests of the co-sinusoidal function. θ will be 0 degrees when the crests are perpendicular to the x , or horizontal, axis. θ increases in a counter-clockwise rotation.

λ : (minimal spatial wavelength, ∞] pixels. λ is limited in practice to twice the number of pixels across the longest diagonal in the image. $\lambda = 1/f$ where f : $[0, \text{maximal spatial frequency})$. The maximal spatial frequency is the Nyquist frequency and is equal to the image resolution divided by 2.

δ : $[0, 360)$ degrees. δ is defined as $(d/\lambda) \times 360^\circ$, where d is the distance between the origin of the cell (upper-left corner of the cell) and the location of the first crest of the co-sinusoidal function in a positive direction in x (see Figure 3).

The value of each of these parameters can be quantized to create a limited set of discrete triplets $(\theta, \lambda, \delta)$. Applying each triplet in this set to the co-sinusoidal function noted above will generate a corresponding set of finger pattern cell structures.

Consider then, representing θ , λ and δ by l , m and n bits, respectively. This implies that the values for θ , λ and δ will be as shown in the following tables:

Table 1 — l -bit representation for θ

Value (l -bits)	θ
0...000	0
0...001	$\frac{1}{2^l} \times 180$
0...010	$\frac{2}{2^l} \times 180$
...	...
1...110	$\frac{2^l - 2}{2^l} \times 180$
1...111	$\frac{2^l - 1}{2^l} \times 180$

Table 2 — m -bit representation for λ

Value (m -bits)	f	λ
0...000	0	∞
0...001	$\frac{1}{2^m} \times \text{Nyquist}$	$\frac{1}{f}$
0...010	$\frac{2}{2^m} \times \text{Nyquist}$	$\frac{1}{f}$
...	...	...
1...110	$\left(\frac{2^m - 2}{2^m} \right) \times \text{Nyquist}$	$\frac{1}{f}$
1...111	$\left(\frac{1}{2^m} \right) \times \text{Nyquist}$	$\frac{1}{f}$